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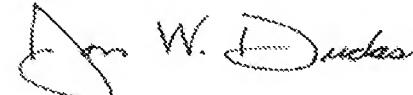
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Express Mail Label No. EL 912754419 US		
INVENTOR(S)		
Given Name (first and middle if any)		Family Name or Surname
MARK	FRANCIS	RUMREICH
		Residence (City and either State or Foreign Country)
		INDIANAPOLIS IN US
<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto		
TITLE OF THE INVENTION (500 characters max)		
APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING		
Direct all correspondence to: CORRESPONDENCE ADDRESS		
<input type="checkbox"/> Customer Number		<input type="text"/>
OR		
<input type="checkbox"/>	Firm or Individual Name JOSEPH S. TRIPOLI, THOMSON LICENSING INC.	
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ENCLOSED APPLICATION PARTS (check all that apply)		
<input checked="" type="checkbox"/> Specification Number of Pages 6		<input type="checkbox"/> CD(s), Number _____
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets 4		<input type="checkbox"/> Other (specify) _____
<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.		FILING FEE AMOUNT (\$)
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Respectfully submitted,
SIGNATURE

[Page 1 of 2]

Date March 22, 2004

TYPED or PRINTED NAME CHRISTINEJOHNSON

REGISTRATION NO 38507
Docket Number: PU040040

TELEPHONE 1 609 734 6892

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17858 US PTO
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FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

Applicant claims small entity status. See 37 CFR 1.27

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Application Number	
Filing Date	
First Named Inventor	MARK FRANCIS RUMREICH
Examiner Name	
Art Unit	
Attorney Docket No.	PU040040

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ADDITIONAL FEES <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; width: 15%;">Large Entity</th> <th style="text-align: left; width: 15%;">Small Entity</th> <th colspan="4" style="text-align: left;">Fee Description</th> <th style="text-align: right; width: 15%;">Fee Paid</th> </tr> </thead> <tbody> <tr> <td>Fee Code</td> <td>Fee (\$)</td> <td>Fee Code</td> <td>Fee (\$)</td> <td>Fee Description</td> <td>Fee Paid</td> <td></td> </tr> <tr> <td>1051</td> <td>130</td> <td>2051</td> <td>65</td> <td>Surcharge - late filing fee or oath</td> <td></td> <td></td> </tr> <tr> <td>1052</td> <td>50</td> <td>2052</td> <td>25</td> <td>Surcharge - late provisional filing fee or cover sheet.</td> <td></td> <td></td> </tr> <tr> <td>1053</td> <td>130</td> <td>1053</td> <td>130</td> <td>Non-English specification</td> <td></td> <td></td> </tr> <tr> <td>1812</td> <td>2,520</td> <td>1812</td> <td>2,520</td> <td>For filing a request for reexamination</td> <td></td> <td></td> </tr> <tr> <td>1804</td> <td>920*</td> <td>1804</td> <td>920*</td> <td>Requesting publication of SIR prior to Examiner action</td> <td></td> <td></td> </tr> <tr> <td>1805</td> <td>1,840*</td> <td>1805</td> <td>1,840*</td> <td>Requesting publication of SIR after Examiner action</td> <td></td> <td></td> </tr> <tr> <td>1251</td> <td>110</td> <td>2251</td> <td>55</td> <td>Extension for reply within first month</td> <td></td> <td></td> </tr> <tr> <td>1252</td> <td>420</td> <td>2252</td> <td>210</td> <td>Extension for reply within second month</td> <td></td> <td></td> </tr> <tr> <td>1253</td> <td>950</td> <td>2253</td> <td>475</td> <td>Extension for reply within third month</td> <td></td> <td></td> </tr> <tr> <td>1254</td> <td>1,480</td> <td>2254</td> <td>740</td> <td>Extension for reply within fourth month</td> <td></td> <td></td> </tr> <tr> <td>1255</td> <td>2,010</td> <td>2255</td> <td>1,005</td> <td>Extension for reply within fifth month</td> <td></td> <td></td> </tr> <tr> <td>1401</td> <td>330</td> <td>2401</td> <td>165</td> <td>Notice of Appeal</td> <td></td> <td></td> </tr> <tr> <td>1402</td> <td>330</td> <td>2402</td> <td>165</td> <td>Filing a brief in support of an appeal</td> <td></td> <td></td> </tr> <tr> <td>1403</td> <td>290</td> <td>2403</td> <td>145</td> <td>Request for oral hearing</td> <td></td> <td></td> </tr> <tr> <td>1451</td> <td>1,510</td> <td>1451</td> <td>1,510</td> <td>Petition to institute a public use proceeding</td> <td></td> <td></td> </tr> <tr> <td>1452</td> <td>110</td> <td>2452</td> <td>55</td> <td>Petition to revive – unavoidable</td> <td></td> <td></td> </tr> <tr> <td>1453</td> <td>1,330</td> <td>2453</td> <td>665</td> <td>Petition to revive – unintentional</td> <td></td> <td></td> </tr> <tr> <td>1501</td> <td>1,330</td> <td>2501</td> <td>665</td> <td>Utility issue fee (or reissue)</td> <td></td> <td></td> </tr> <tr> <td>1502</td> <td>480</td> <td>2502</td> <td>240</td> <td>Design issue fee</td> <td></td> <td></td> </tr> <tr> <td>1503</td> <td>640</td> <td>2503</td> <td>320</td> <td>Plant issue fee</td> <td></td> <td></td> </tr> <tr> <td>1460</td> <td>130</td> <td>1460</td> <td>130</td> <td>Petitions to the Commissioner</td> <td></td> <td></td> </tr> <tr> <td>1807</td> <td>50</td> <td>1807</td> <td>50</td> <td>Processing fee under 37 CFR 1.17 (q)</td> <td></td> <td></td> </tr> <tr> <td>1806</td> <td>180</td> <td>1806</td> <td>180</td> <td>Submission of Information Disclosure Stmt</td> <td></td> <td></td> </tr> <tr> <td>8021</td> <td>40</td> <td>8021</td> <td>40</td> <td>Recording each patent assignment per property (times number of properties)</td> <td></td> <td></td> </tr> <tr> <td>1809</td> <td>770</td> <td>2809</td> <td>385</td> <td>Filing a submission after final rejection (37 CFR § 1.129(a))</td> <td></td> <td></td> </tr> <tr> <td>1810</td> <td>770</td> <td>2810</td> <td>385</td> <td>For each additional invention to be examined (37 CFR § 1.129(b))</td> <td></td> <td></td> </tr> <tr> <td>1801</td> <td>770</td> <td>2801</td> <td>385</td> <td>Request for Continued Examination (RCE)</td> <td></td> <td></td> </tr> <tr> <td>1802</td> <td>900</td> <td>1802</td> <td>900</td> <td>Request for expedited examination of a design application</td> <td></td> <td></td> </tr> <tr> <td colspan="4">Other fee (specify) _____</td> <td></td> <td></td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;">*Reduced by Basic Filing Fee Paid</td> <td style="text-align: right;">SUBTOTAL (3)</td> <td style="text-align: right;">(\$) 0</td> <td></td> </tr> </tbody> </table>				Large Entity	Small Entity	Fee Description				Fee Paid	Fee Code	Fee (\$)	Fee Code	Fee (\$)	Fee Description	Fee Paid		1051	130	2051	65	Surcharge - late filing fee or oath			1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.			1053	130	1053	130	Non-English specification			1812	2,520	1812	2,520	For filing a request for reexamination			1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action			1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action			1251	110	2251	55	Extension for reply within first month			1252	420	2252	210	Extension for reply within second month			1253	950	2253	475	Extension for reply within third month			1254	1,480	2254	740	Extension for reply within fourth month			1255	2,010	2255	1,005	Extension for reply within fifth month			1401	330	2401	165	Notice of Appeal			1402	330	2402	165	Filing a brief in support of an appeal			1403	290	2403	145	Request for oral hearing			1451	1,510	1451	1,510	Petition to institute a public use proceeding			1452	110	2452	55	Petition to revive – unavoidable			1453	1,330	2453	665	Petition to revive – unintentional			1501	1,330	2501	665	Utility issue fee (or reissue)			1502	480	2502	240	Design issue fee			1503	640	2503	320	Plant issue fee			1460	130	1460	130	Petitions to the Commissioner			1807	50	1807	50	Processing fee under 37 CFR 1.17 (q)			1806	180	1806	180	Submission of Information Disclosure Stmt			8021	40	8021	40	Recording each patent assignment per property (times number of properties)			1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))			1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))			1801	770	2801	385	Request for Continued Examination (RCE)			1802	900	1802	900	Request for expedited examination of a design application			Other fee (specify) _____							*Reduced by Basic Filing Fee Paid				SUBTOTAL (3)	(\$) 0	
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SUBMITTED BY			Complete (if applicable)		
Name (Print/Type)	CHRISTINE JOHNSON	Registration No. (Attorney/Agent)	38507	Telephone	1 609 734 6892
Signature					
Date	March 22, 2004				

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APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING

Field of the Invention

[0001] The present invention generally relates to a filter to pre-correct video prior to "smooth pixel DLP" processing.

Background of the Invention

[0002] Smooth pixel Digital Light Processing (DLP) "contaminates" each pixel with the upper, lower, left & right adjacent input pixels, thereby blurring the image in some cases. Pre-correction filters for other applications are traditionally either the cascade of vertical and horizontal filters, or involve diagonal coefficients.

These filters involve "noncontaminating pixels" and therefore, in some cases, do not adequately correct the problem. One proposed approach to Digital Light Processing (DLP) is referred to as "Smooth pixel DLP". In this approach, rather than using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. The rotated pixels are referred to as "diamond pixels" (see figure 1).

[0003] According to a proposed technique, in addition to using diamond pixels, smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0004] The modulation produces both primary and secondary pixel sets for each incoming picture, effectively doubling the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as compared to having the combined number of pixels in a non-overlapping arrangement). In other words, each combined pixel is "contaminated" by the four adjacent pixels of the other pixel set. Accordingly, devices and methods for canceling the contamination effect are needed.

Summary of the Invention

[0005] The present invention is an apparatus and method for pre-correcting video to reduce the contamination effect caused by smooth pixel DLP modulation.

Brief Description of the Drawings

Preferred embodiments of the present invention will be described below in more detail, with reference to the accompanying drawings, in which:

- Figure 1 is an illustration of a "diamond pixel" of the prior art.
- Figure 2A is an illustration of a primary pixel set.
- Figure 2B is an illustration of a secondary pixel set.
- Figure 2C is an illustration of a combined pixel set.
- Figure 3A is an illustration of a primary pixel set.
- Figure 3B is an illustration of a primary pixel set.
- Figure 3C is an illustration of a combined pixel set.
- Figure 4 is a diagram of a filter according to an embodiment of the invention.

Detailed Description

[0006] "Smooth pixel DLP" is a term used to refer to Texas Instruments approach to a form of Digital Light Processing. Instead of using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. These are referred to as "diamond pixels" (see figure 1).

[0007] In addition to using diamond pixels, one approach to smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0008] The modulation produces both primary (Figure 2A) and secondary (Figure 2B) pixel sets for each incoming picture. This effectively doubles the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as

compared to having the combined number of pixels in a non-overlapping arrangement) (Figure 3B). In other words, each combined pixel (Figure B) is contaminated by the four adjacent pixels of the other pixel set. The invention is a system and method of substantially canceling this effect.

[0009] According to an embodiment of the invention, each incoming pixel data point directly corresponds to one pixel on the combined pixel grid. For example, in an illustrative embodiment of the invention, the incoming pixel data for one component (in one embodiment YUV, in an alternative embodiment RGB) is as follows:

A	B	C	D	E
F	G	H	I	J
K	L	M	N	O

[0010] Figures 3A, 3B and 3C show how the above input samples are mapped to the smooth pixels. Referring to figure 3, each input pixel is "contaminated" by the four adjacent pixels of the other pixel set. For example, the H pixel is contaminated by the C, G, I and M pixels. In other words, each pixel is contaminated by the upper, lower, left and right adjacent pixels in the incoming pixel data. By using a pre-correction filter of the present invention on the incoming pixel data, it's possible to offset the degradation due to this contamination effect.

[0011] In one embodiment of the invention, a two-dimensional precorrection filter configured as follows is employed:

$$\begin{matrix} \alpha \\ \alpha & \beta & \alpha \\ \alpha \end{matrix}$$

[0012] In one embodiment of the invention, alpha is -1/8. This provides provide unity DC gain and optimum pre-correction. In an embodiment of the invention, Beta is 1 - 4*alpha for unity DC gain. In one embodiment of the invention, for alpha = -1/8, beta is 3/2. In effect, the filter of an embodiment of the invention subtracts out contaminating

pixel information from each input pixel. By processing the input pixel data with this filter, pre-corrected input pixel data is provided. The pre-corrected pixel data is then processed by smooth pixel processing.

A	B	C	D	E		A'	B'	C'	D'	E'
F	G	H	I	J	→	F'	G'	H'	I'	J'
K	L	M	N	O		K'	L'	M'	N'	O'

[0013] Figure 4 illustrates a filter in accordance with an embodiment of the invention. In this embodiment, eight levels of pre-correction are provided, from alpha = 0 to alpha = -7/32, in 1/32 steps.

[0014] While foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A method for filtering pixel data comprising the steps of:
applying a pre-correction filter to said pixel data to provide pre-corrected pixel
5 data;
smooth pixel processing said pre-corrected pixel data.

Abstract of the Disclosure

A method and apparatus are disclosed for filtering pixel data. The method comprises the steps of applying a pre-correction filter to the pixel data to provide pre-corrected pixel data. The pre-corrected pixel data is subjected to smooth pixel
5 processing.

10

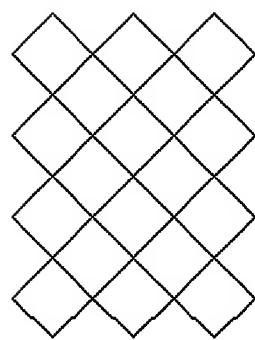
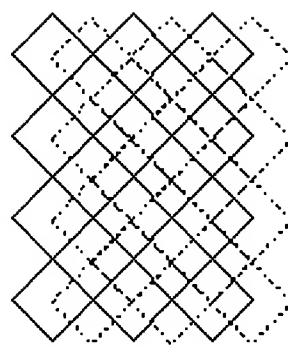
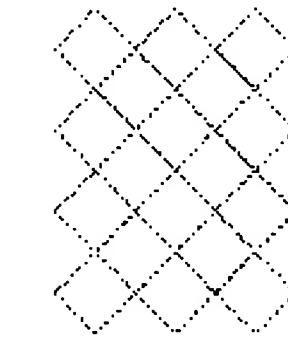


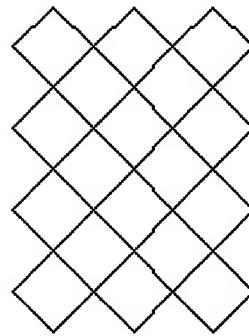
Figure 1



Combined pixel set



Secondary pixel set



Primary pixel set

Figure 2A

Figure 2B

Figure 2C

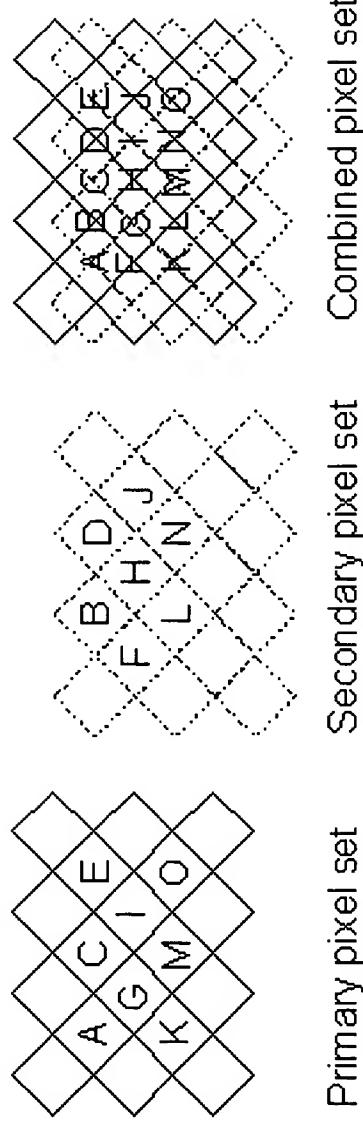


Figure 3A

Figure 3B

Figure 3C

Figure 4

